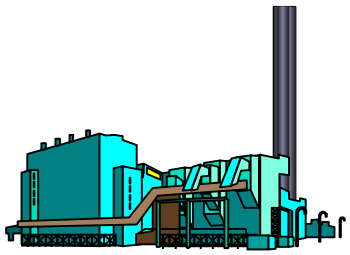
Analysis of Emissions Reduction Options for the Electric Power Industry



Office of Air and Radiation

U.S. Environmental Protection Agency

April 1999

Reasons for the Study

- Continuation of Multiple Pollutant Analysis for the Electric Power Industry
- Support Regulatory Determination for Mercury Emissions from Coal-fired Power Plants
- Settlement with Natural Resources Defense Council

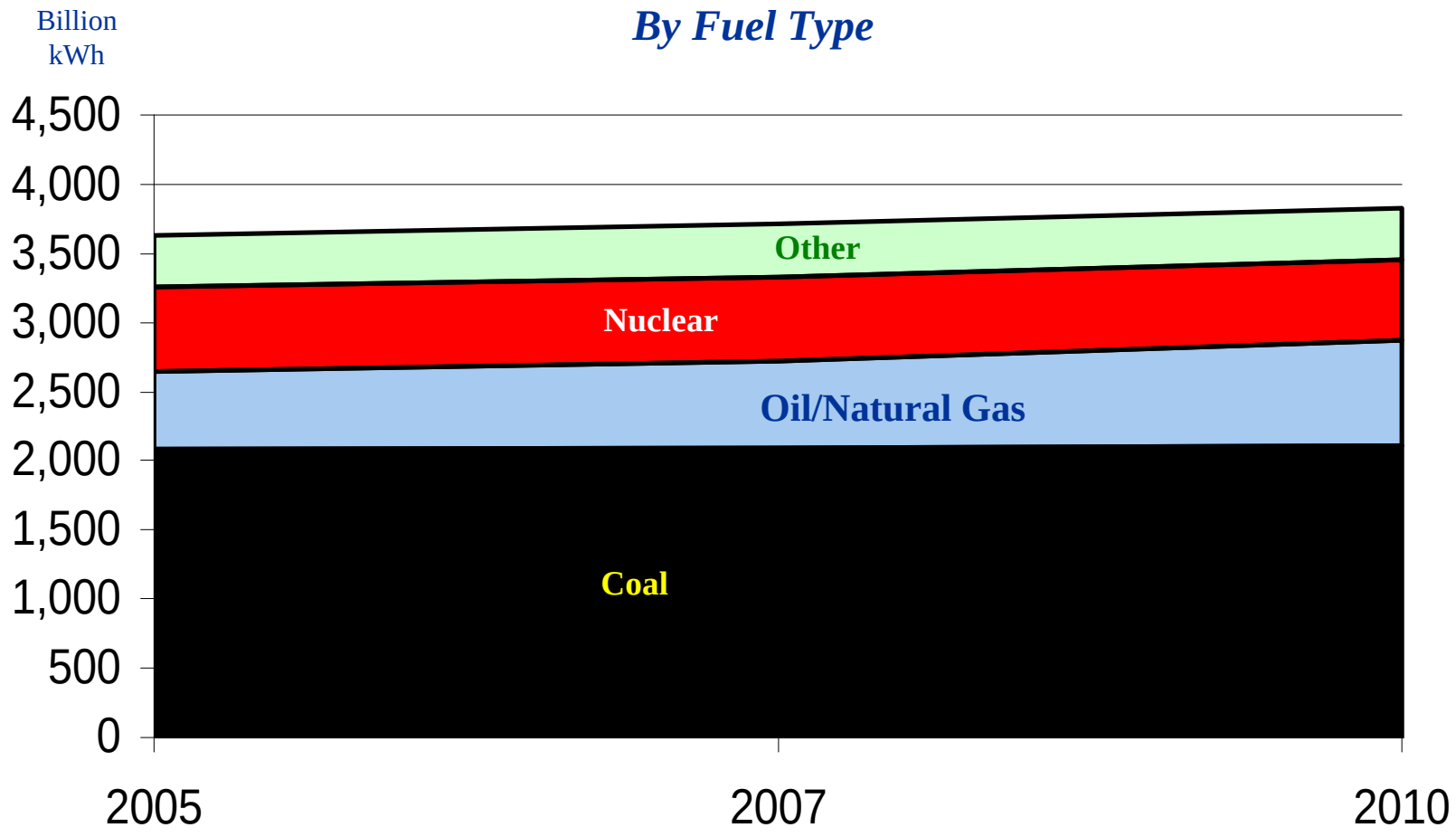
Study Examines Hypothetical Options

- **Base Case:** CAAA Title IV, NSPS, BACT/RACT, State Controls, and the NO_x SIP Call. Focus on 2005 to 2010.
- **Hypothetical Options** Designed to Lower Air Emissions of:
  - SO_2 (for Fine Particles)
  - Carbon
  - Mercury
  - SO_2 and Carbon
  - SO_2, Carbon and Mercury
- Consider Controls through Cap-and-Trade -- Also Maximum Achievable Control Technology (MACT) for Mercury

General Limitations

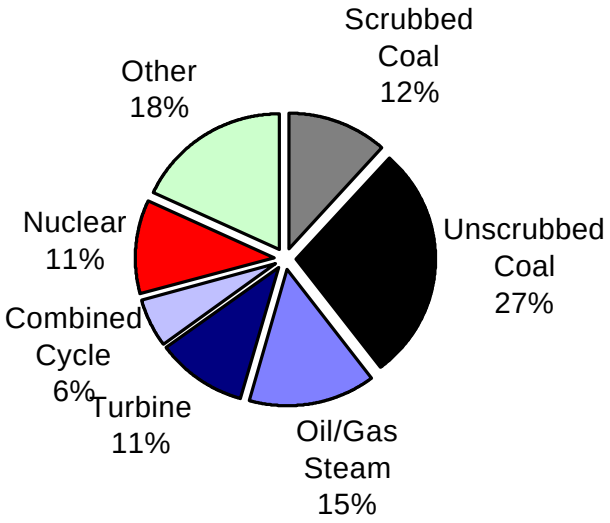
- **The Study Examines Hypothetical Options. The Options Do Not Represent EPA or Administration Positions.**
- **Mercury Pollution Control Costs and Removal Rates Are Preliminary Estimates that Use Best Available Information.**
- Deregulation at the Wholesale Power Level Occurs throughout the U.S. by 2005.
- Implementation of Options Occurs Smoothly.
- The Costs of the Administrative Elements of the Options Are Not Included.
- Data Limitations Exist on Pollution Controls on Boilers.

Base Case Electric Generation Forecast

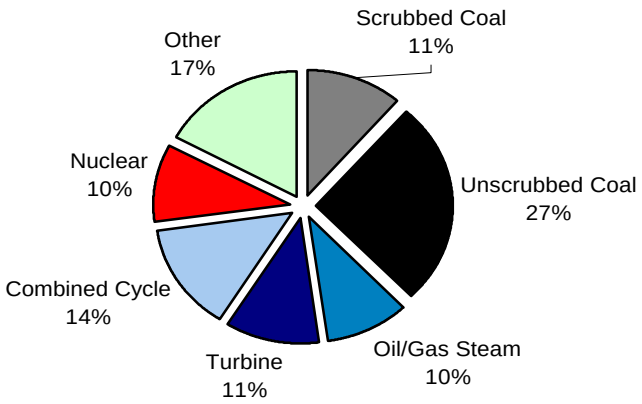


Base Case Generation Capacity Forecast

2005 Generation Capacity: 770 GW

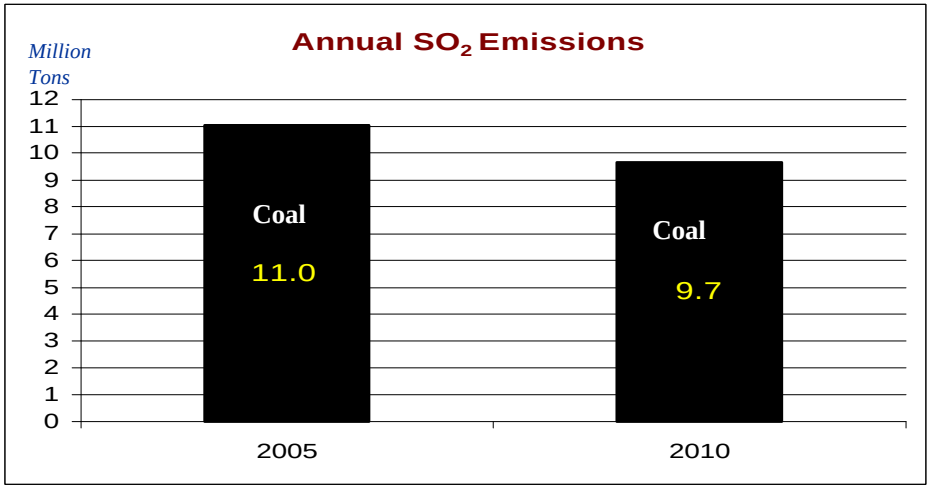


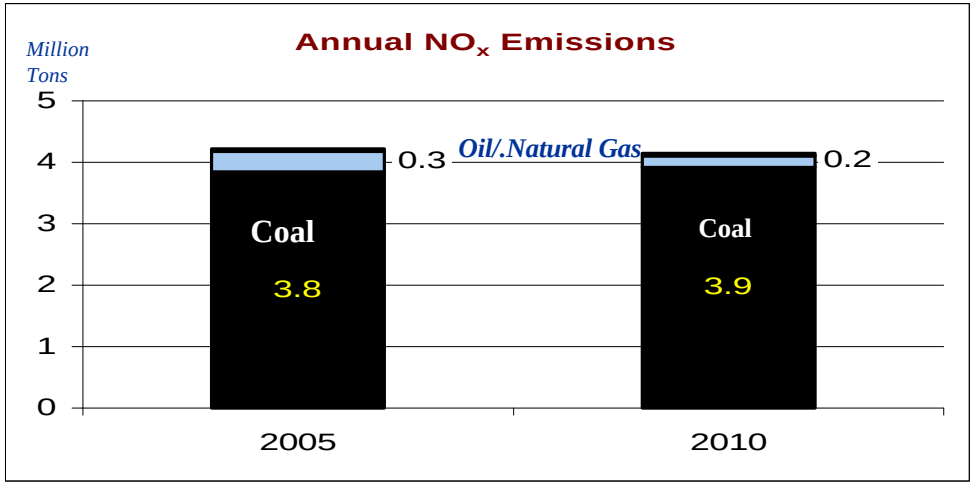
2010 Generation Capacity: 805 GW

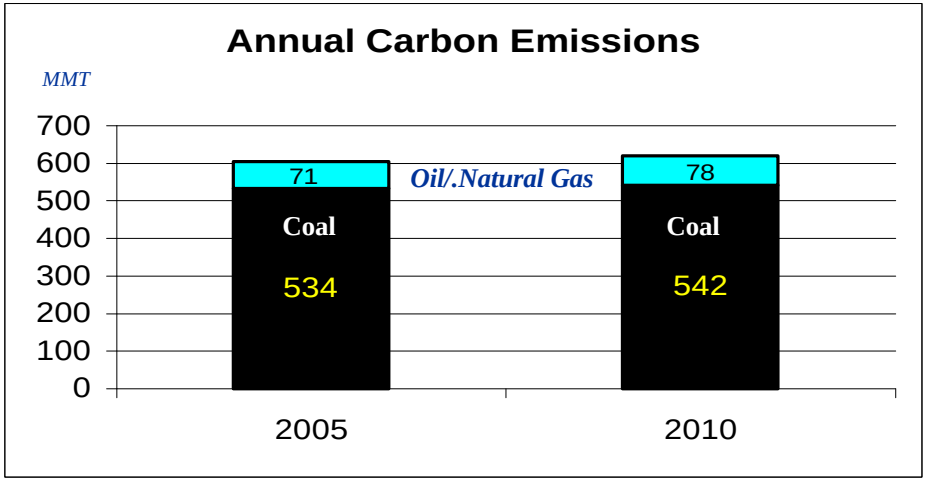


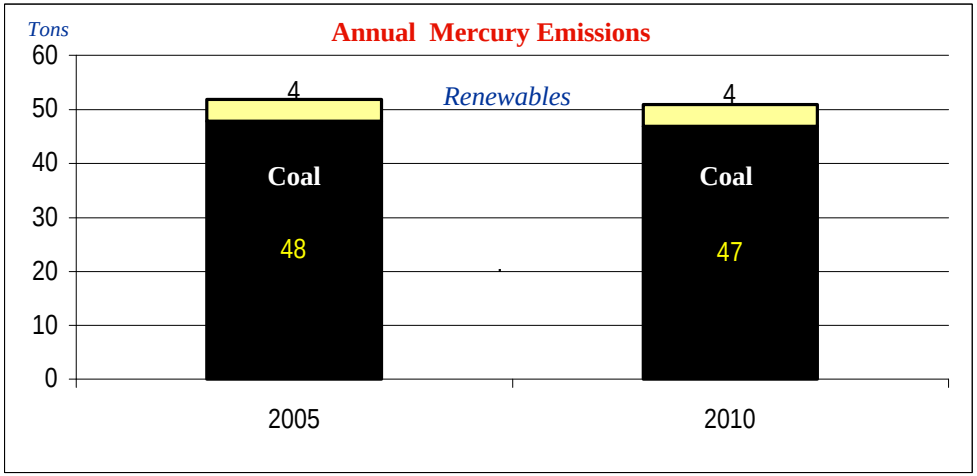
- Coal-fired Generation Has 305 GW and 304 GW of Capacity in 2005 and 2010, Respectively.
- Oil/Natural Gas-fired Generation Has 240 GW and 282 GW of Capacity in 2005 and 2010, Respectively.

Emissions by Fuel Source for Major Air Pollutants from the Electric Power Industry in 2005 and 2010



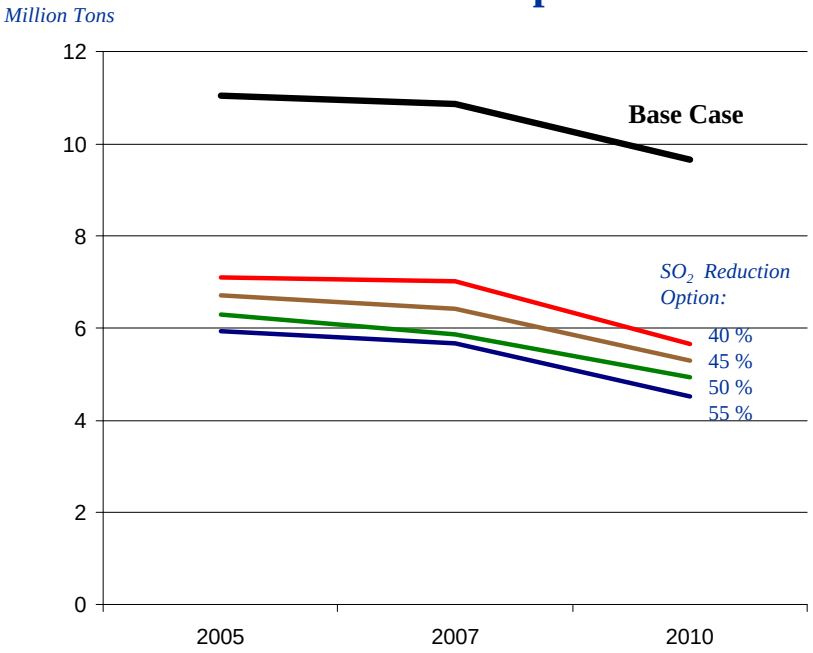




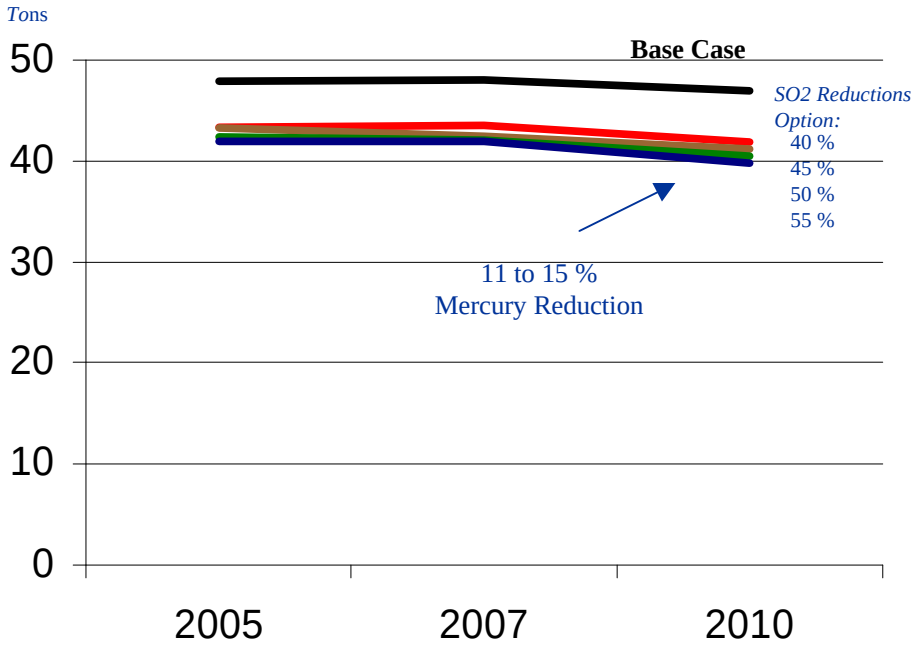


Further SO_2 Reductions Lower Mercury Emissions

SO_2 Emissions of the Base Case and SO_2 Reduction Options



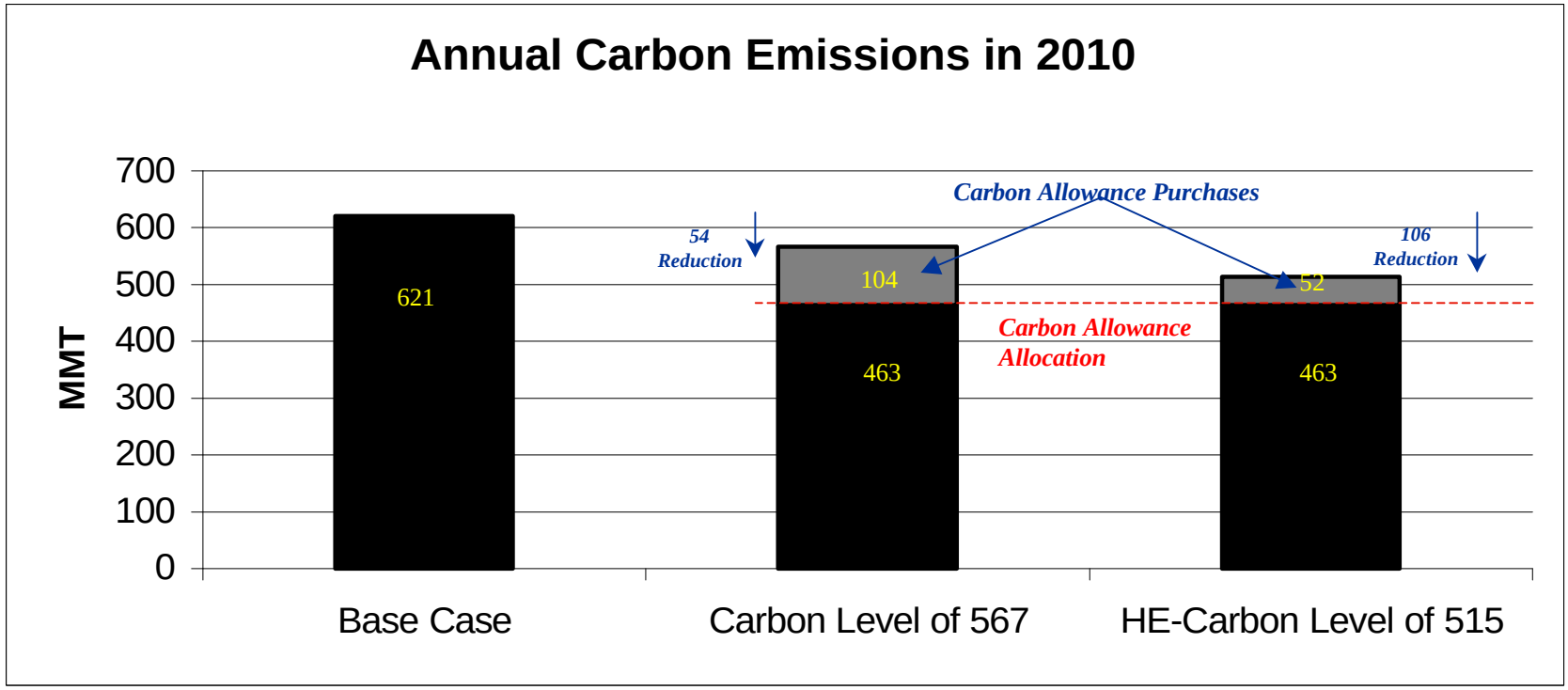
Mercury Emissions from Coal-fired Units in the Base Case and SO_2 Reduction Options



- Mercury Reductions Occur, because Scrubbers Are Installed and More Power Is Supplied by Natural Gas.
- Some Carbon and NO_x Emissions Reductions Occur.
- In 2010, the Annual Costs for the SO_2 Reduction Options Range from $1.9 to $2.8 Billion.
- Total Coal Demand Drops and Important Supply Shifts Occur.

Note: All Costs Are in 1990$. A Recent MIT Paper by Ellerman et al, "The Costs of Reducing Utility SO_2 Emissions -- Not as Low as You Might Think," Indicates that in 1989 EPA and the Edison Electric Institute (the "Industry Estimate") Had Midpoint Estimates for the Title IV SO_2 Allowance Trading Program of $4.2 and $4.9 Billion, Respectively. EPA Estimates that in 2010 an Option for 50% SO_2 Reduction Beyond Title IV Costs $2.5 Billion and that the Title IV SO_2 Allowance Trading Program Will Cost $1.6 Billion. This Leads to Total Annual Costs of Both SO_2 Reduction Actions of $4.1 Billion in 2010. More Recent Resources for the Future and Electric Power Research Institute Cost Estimates of the Title IV Program Suggest that EPA's Estimate of the Program Costs May Be Too High.

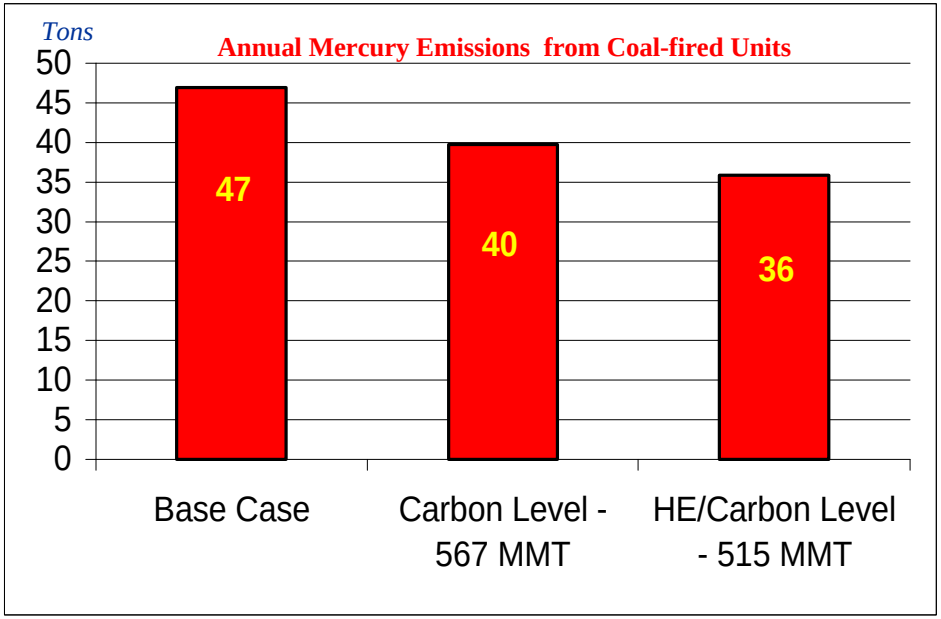
The Study Examined Hypothetical Carbon Reduction Options that Rely on International Trading. They Are in the Range under Discussion.

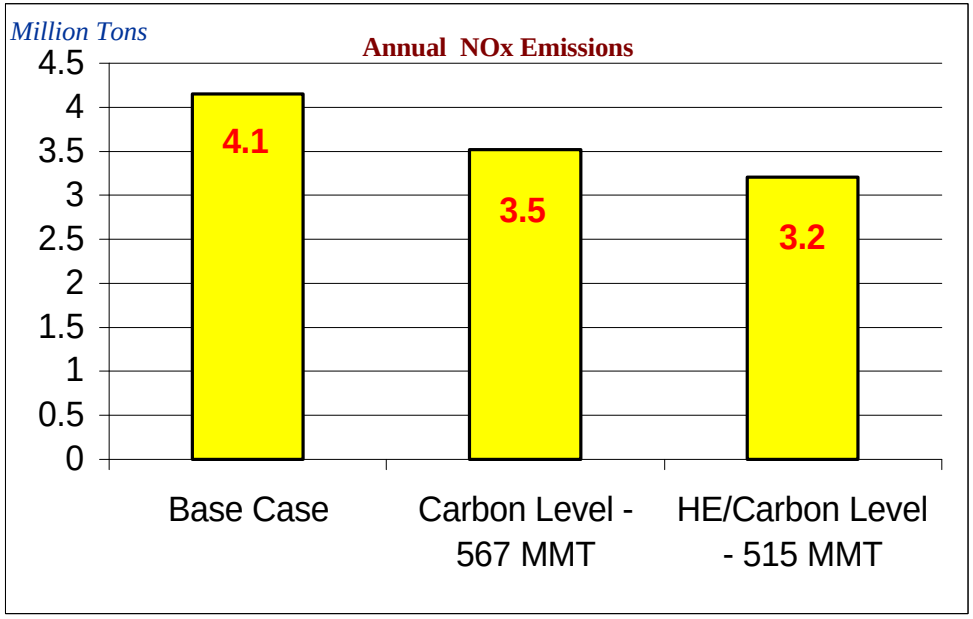


- In 2010:
  - The *Carbon Level of 567 MMT in 2008 Option* Has an Annual Direct System Cost of $1.0 Billion, Plus the Power Industry Will Purchase Allowances that Annually Cost $2.0 Billion.
  - The *High Efficiency / Carbon Level of 515 MMT in 2008 Option* Has an Annual Direct System Cost of $2.0 Billion, Plus the Power Industry Will Purchase Allowances that Annually Cost $1.0 Billion. Power Users Are Annually Investing $5.0 Billion and Saving $7.9 Billion. There Is a Net Cost of $.1 Billion.

Note: All Costs Are in 1990$. Carbon Allowances Are Valued at CEA Value in 1996$ of $23 per Ton
In the HE-Carbon Level of 515 MMT Case, Demand Reduction Lowers Emissions to 590 MMT Annually Before Generation System Changes

The Hypothetical Carbon Reduction Options Lower Mercury and NO_x Emissions Significantly in 2010

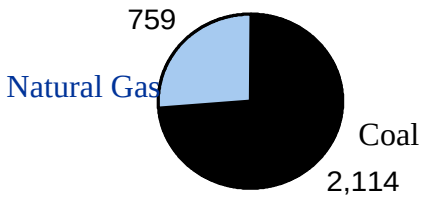




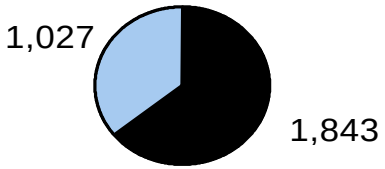
- Carbon Reduction Options Lower:
  - Mercury Emissions from Coal-fired Units: 15% to 23%
  - Annual NO_x Emissions from All Units: 15% to 23%
- There Is Not Much Change in SO_2 Due to the Emissions Cap.

How the Electric Power Industry Lowers Carbon Emissions to 567 MMT in 2010

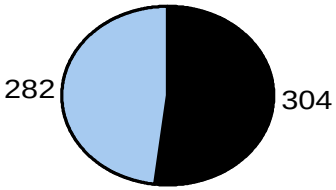
Fossil Electric Generation in 2010 in the Base Case (Billion kWh)



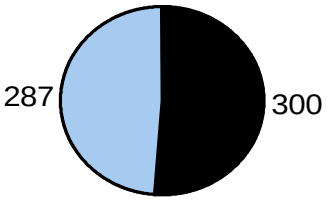
Fossil Electric Generation in 2010 for 567 MMT Carbon Level (Billion kWh)



Fossil Generation Capacity in 2010 in the Base Case (GW)



Fossil Generation Capacity in 2010 for 567 MMT Carbon Level (GW)



Combined SO_2 and Carbon Reduction Options Lead to Further Air Emission Reductions

- Study Has Two SO_2 and Carbon Reduction Options:
  - *50% Reduction in SO_2/Carbon Level of 567 MMT (Combined Option 1)*
  - *50% Reduction in SO_2/ HE - Carbon Level of 515 MMT (Combined Option 2)*
- In 2010, the SO_2 and Carbon Reduction Options Lower:
  - Annual SO_2: 52% to 53%
  - Annual Carbon: 9% to 17%
  - Annual NO_x: 15% to 24%
  - Annual Mercury from Coal-Fired Units: 26% to 34%
- In 2010, the Annual Costs Are:
  - *Combined Option 1*: $3.0 Billion System Operation Costs Plus Allowance Costs of $2.0 Billion. Total: $5.0 Billion
  - *Combined Option 2:* $3.6 Billion System Operation, $5.0 Investment in Energy Reduction, $7.9 Savings from Energy Reduction, and $1.0 Billion for Allowances. Net Costs: $1.8 Billion

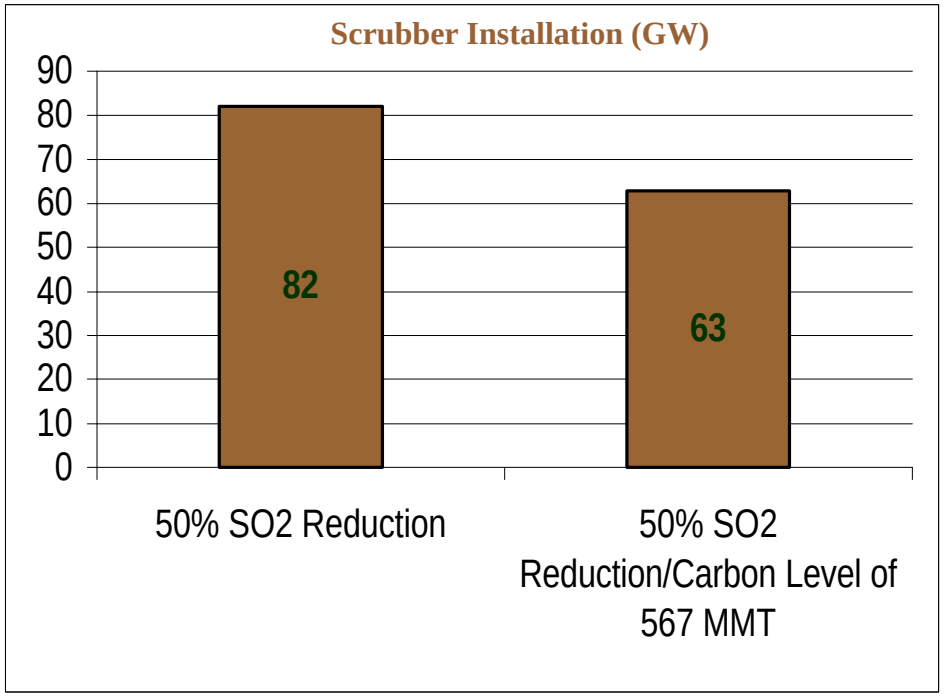
Note: All Costs Are in 1990$. Carbon Allowances Are Valued at CEA Value in 1996$ of $23 per Ton.

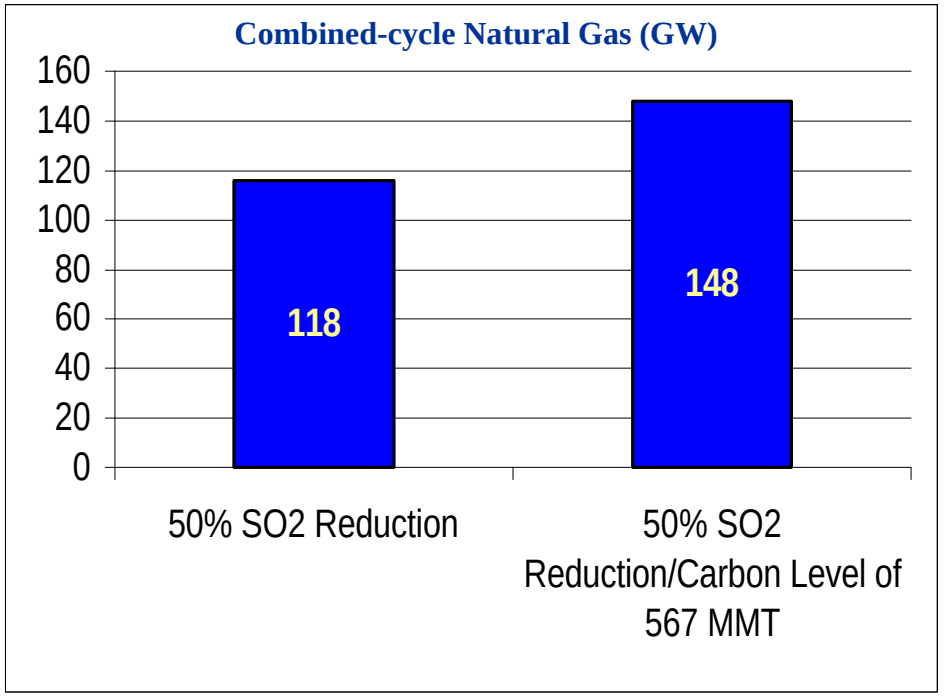
Two Other Important Insights Emerge from Examining the Combined SO_2 and Carbon Options

- The Combined SO_2 and Carbon Options Have Lower Costs than Individual Option Analyses Suggest. In 2010:
  - The 50 Percent SO_2 Reduction Option ($2.5 Billion Cost) and the Carbon Level of 567 MMT in 2008 ($3.0 Billion Cost) Appear to Have a Total Cost of $5.5 Billion. However, in the Combined Option Analysis, the Annual Cost Was $5.0 Billion -- $500 Million Less.
  - The 50 Percent SO_2 Reduction Option ($2.5 Billion Cost) and the High Efficiency/Carbon Level of 515 MMT in 2008 Option with ($.1 Billion Cost) Appear to Have a Total Cost of $2.6 Billion. However, in the Combined Option Analysis the Cost Was $1.8 Billion -- $800 Million Less.
  - The Electric Power Industry Will Add Different Controls, If It Sees Only Part of Its Future in the Next 10 Years, Rather Than All of It (*See Next Page Example.)*

Note: All Costs Are in 1990$. Carbon Allowances Are Valued at CEA Value in 1996$ of $23 per Ton.

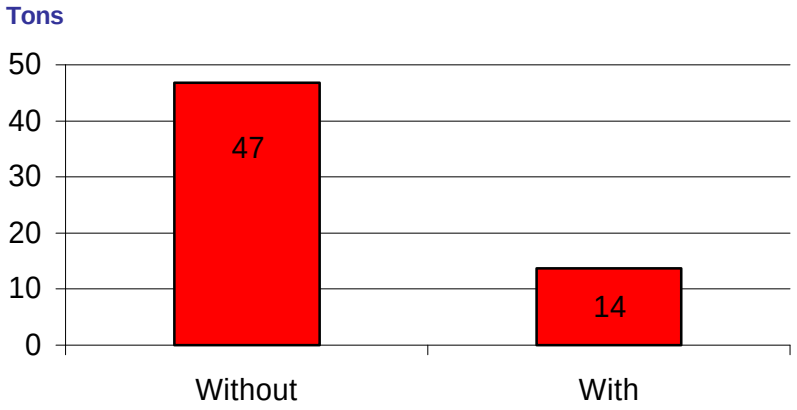
Looking at the 50% SO_2 Reduction Option and the 50% SO_2 Reduction/Carbon Level of 567 MMT in 2008 Option



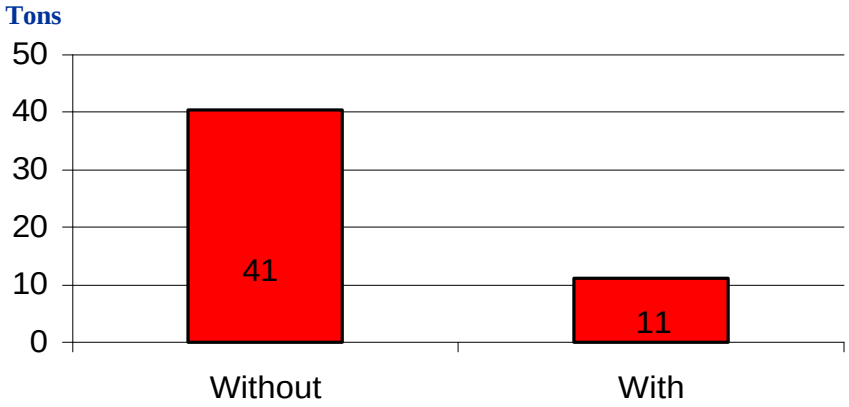


Mercury Emission Changes under Different "Baselines" for a MACT for Coal-fired Generation Units

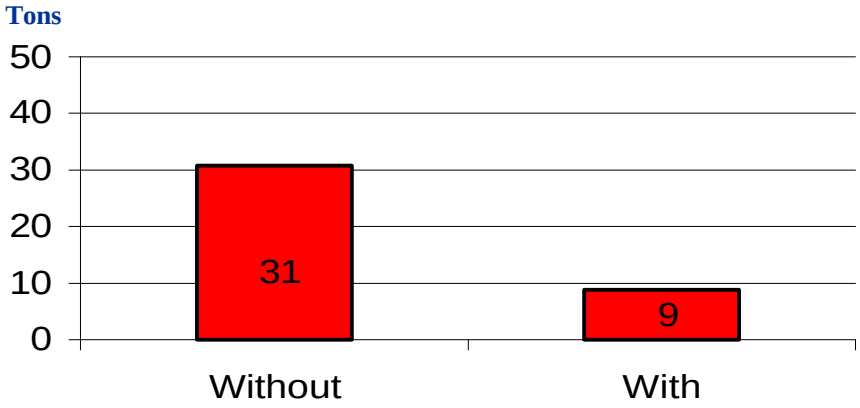
Mercury Emissions in 2010 in the Base Case without and with MACT



Mercury Emissions in 2010 with 50% SOx Reduction Baseline without and with MACT



Mercury Emissions in 2010 with 50% SOx Reduction /HE- Carbon Emission Level of 515 MMT Baseline without and with MACT

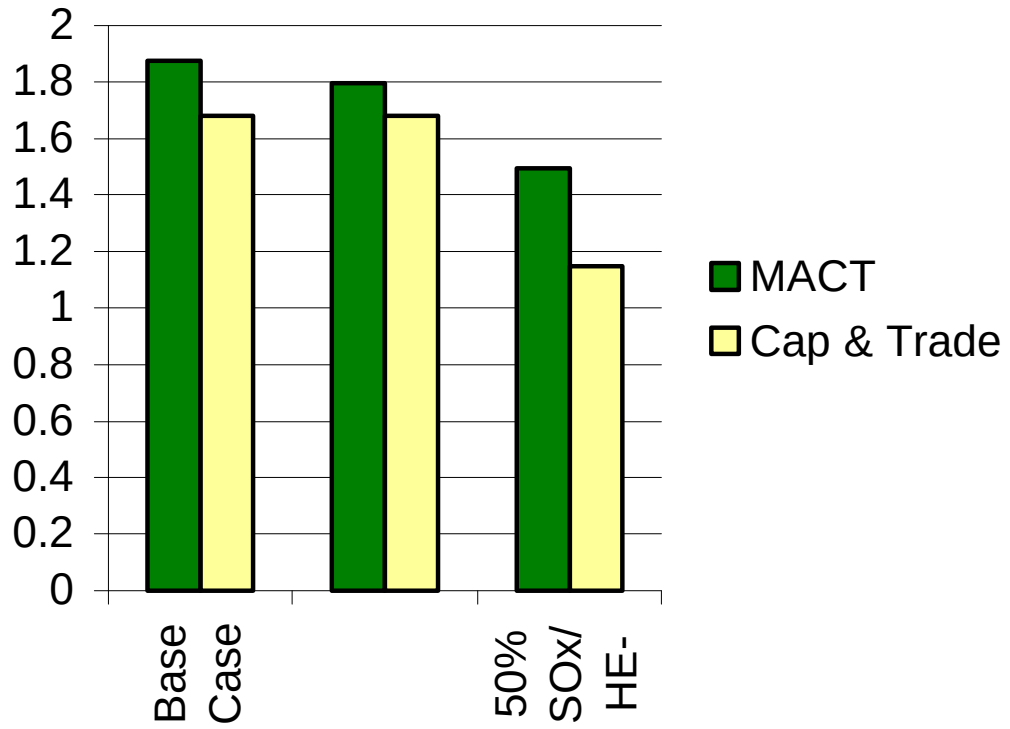


- In All "Baselines" in 2010, There Is More than a 70 Percent Reduction in Mercury Emissions from Coal-fired Units -- 22 to 33 Tons Annually.

Preliminary Estimates of the

Costs of Mercury MACT and Cap-and-Trade for Coal-fired Power Plants under Three Baselines in 2010

(Billions of 1990$)

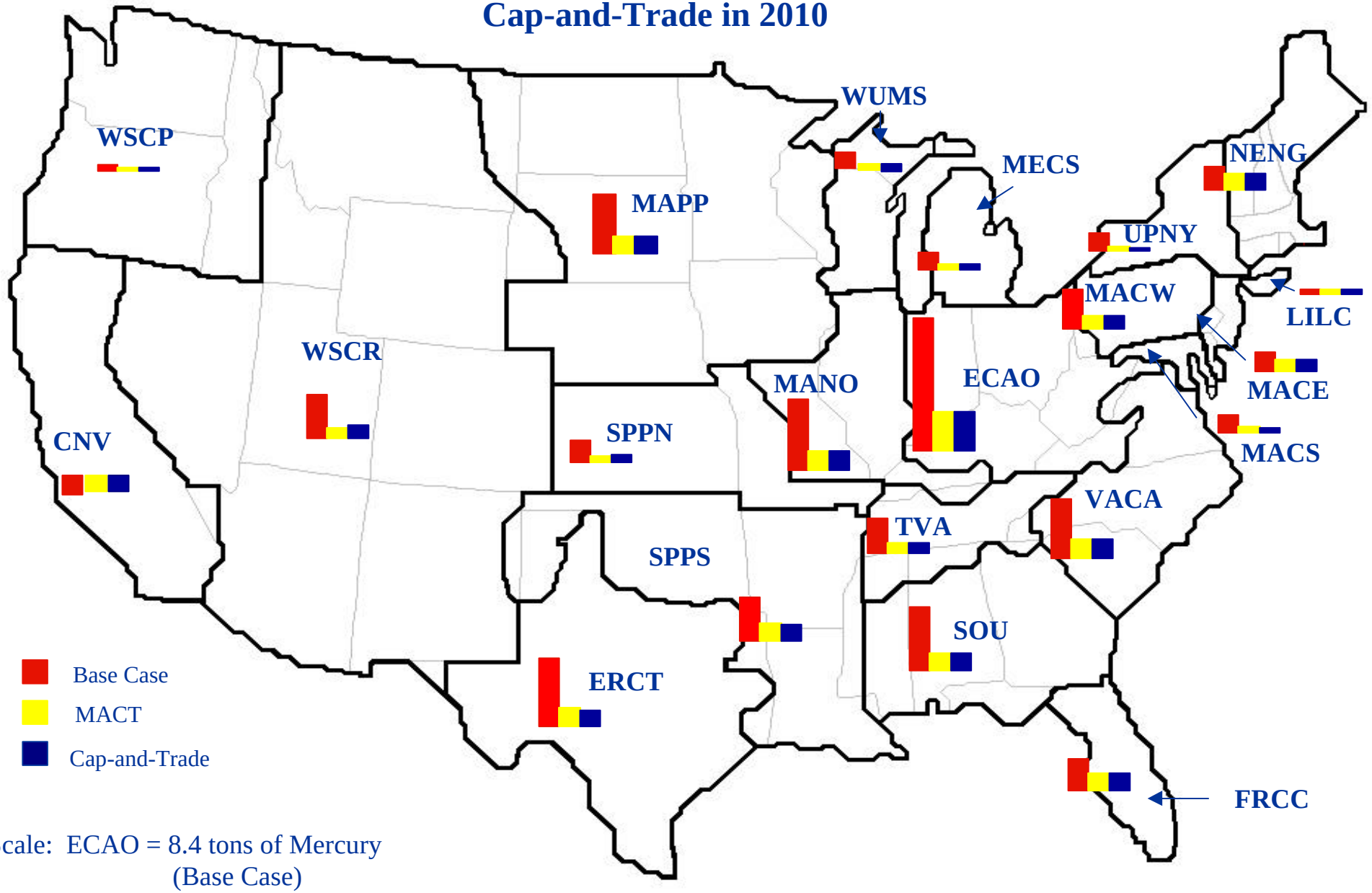


- The Annual Cost of the NO_x SIP Call Is $1.4 Billion.
- In the *Mercury Study Report To Congress*, EPA Estimated that a "90 Percent" Reduction (37 tons) Has an Annual Cost of $5 Billion.

Two Other Important Insights about Air Emissions Emerge from the Preliminary Mercury Analysis

- Mercury Controls Led to Limited Changes in Other Pollutants.
- When Mercury Cap-and-Trade Alternatives Were Analyzed, They Show Similar Regional Reductions to the Mercury MACT. However, More Research Is Warranted, Particularly with Regard to Local Impacts.

Mercury Emissions in the Base Case and Hypothetical Mercury MACT and Cap-and-Trade in 2010



Scale: ECAO = 8.4 tons of Mercury (Base Case)

Carrying the Study's Preliminary Cost Analysis a Step Further Provides Other Important Insights

- The Combined Option of a *Mercury MACT with Further SO_2 Reduction and Carbon Reduction that Is Complemented by a Significant Electricity Demand Reduction (High Efficiency/Carbon Level of 515 MMT)* Annually Costs $3.2 Billion in 2010.
- The Combined Option of a *Mercury Cap-and-Trade with Further SO_2 Reduction and Carbon Reduction that Is Complemented by a Significant Electricity Demand Reduction* Annually Costs $2.9 Billion in 2010.

- To Place These Costs in Perspective...
  - In 2010, the Energy Information Administration Forecasts A Restructured Power Industry with Electricity Sales of $194 Billion and GDP Will Be $9.3 Trillion.
  - EPA Estimates Annual SO_2 Reduction Benefits Alone of $12 to $61 Billion in Just the Eastern U.S. from a *Clean Air Power Initiative* Option that Lowered Power Industry SO_2 Emissions 50% Below Title IV Levels
  - In 1996, National Health Care Expenditures Were $879 Billion.
  - American's Are Expected to Spend $3.3 Billion in 1999 on Home Video Games.

Note: All Dollar Estimates Are in 1990$ Perspective Sources: EIA's *Annual Energy Outlook 1999* (Electricity Sales and GDP), Census Bureau's *Statistical Abstracts of the United States 1998* (Health Care and Video Games), and Abt Associates Memo to EPA, Dated November 1996 (Benefits of SO_2 Reduction).. EPA Benefits Analysis Covered 204 Million People Living in the East of a Resident US Population Predicted to Be 298 Million in 2010..

Findings

- Further SO_2 and Carbon Reductions by the Electric Power Industry Should Lower Mercury Emissions Significantly. Carbon Reduction Options Can Also Lower Summer and Annual NO_x Emissions Significantly.
- Preliminary Analysis Suggests that Mercury Reductions at Coal-fired Generation Units May Not Lower NO_x, SO_2, or Carbon Emissions Significantly.
- Preliminary Analysis Suggests Considering Both MACT and Cap-and-Trade Options for Lowering Mercury Emissions from Coal-fired Units.
- Options for Further SO_2 Reduction Annually Cost $1.9 to $2.8 Billion in 2010.
- In 2010, Carbon Reduction Options Relying on International Trading Can Have Direct Net Costs of $ 3 Billion, or $.1 Billion, If Linked to Reductions in Electricity Use.
- Preliminary Analysis of Mercury Control Options Suggests that Controls on Coal-fired Units May Annually Cost under $2 Billion in 2010.
- Analysis of Combined Options Shows that the Total Costs of a Set of Actions Is Less than a "Piecemeal" Approach.
- Study Shows the Value of Knowing What Future Requirements Will Be Over Time. Nothing in the Report Supports a Need to Delay CAAA Actions.

Note: All Costs Are in 1990$. Carbon Allowances Are Valued at CEA Value in 1996$ of $23 per Ton.